Washington State
Department of Transportation

MEMORANDUM

July 31, 2003

TO: Mark Russell
Northwest Region NB82-55

FROM: Tony Allen/William Hegge
EEP Geotechnical Branch, 47365

SUBJECT: SR 543, OL-3500
Geotechnical Report Addendum No. 2
SR 5 to International Boundary Modifications

## INTRODUCTION

Our office prepared a geotechnical report entitled "Geotechnical Report, SR 543, SR5 to International Boundary Modifications" dated August 8, 2002 and an Addendum No. 1 dated March 18, 2003. The location of the project site is shown on the Vicinity Map (Figure 1 in Appendix A). The report contained geotechnical recommendations for various structures along the proposed project, including retaining walls, signal standards, and a new bridge at D Street.

Asad Bushnaq of the Bridge Design Office informed us that unless some of the lateral pressures were reduced, the diameter of the cylinder piles would have to be increased, raising the cost of the project. During our discussion, we identified two methods of accomplishing this. The first method is to install French drains behind the walls. This method is usable for any wall on the project site. However, due to the relatively poor subsurface conditions, we decided to limit the depth of the French drains behind the walls to 10 feet to reduce the magnitude of trench caving and the costs associated with additional excavation and backfill. The second method for reducing the lateral forces is to regrade the ground surface behind the wall; to eliminate the 2H:1V (Horizontal:Vertical) slopes that increase the lateral pressure. This approach is limited to walls 5, 6 and 7 where 2H:1V slopes are planned. However, the presence of existing roads behind walls 5 and 6 along the western edge of the project prevents the use of this approach there. Therefore, additional grading to reduce wall pressures is limited to wall 7.

Mr. Bushnaq provided us with the following information regarding where these remedial measures are desired:

**Table 1 Proposed Remedial Measure Locations**

| Wall No. | Limits of Proposed French Drain (Station) | Limits of Proposed Wall Backslope Regrading (Station) | Applicable Borings |
|---|---|---|---|
| 1 | LL 1+660 to 1+700 | N/A | TH-4-99 |
| 2 | LL 1+730 to 1+765 | N/A | TH-6-01 |
| 3 | LR 1+660 to 1+700 | N/A | TH-11-99 |
| 4 | LR 1+730 to 1+765 | N/A | TH-1-99 |
| 5 | LL 1+530 to 1+707 | N/A | TH-3-99 and TH-4-99 |
| 6 | LL 1+725 to 1+890 | N/A | TH-6-01, TH-2-99, TH-8-99 and TH-8-01 |
| 7 | LR 1+530 to 1+707 | N/A | TH-5-01, TH-12-99 and TH-11-99 |
| 7 | | LR 1+650 to 1+707 | TH-12-99 and TH-11-99 |
| West Bridge Abutment 1 | LL 1+707 to 1+725 | N/A | TH-4-99 and TH-6-01 |
| West Bridge Abutment 2 | LL 1+700 to 1+730 | N/A | TH-4-99 and TH-6-01 |
| East Bridge Abutment 1 | LR 1+700 to 1+730 | N/A | TH-11-99 and TH-1-99 |
| East Bridge Abutment 2 | LR 1+707 to 1+723 | N/A | TH-11-99 and TH-1-99 |

He also informed us that the drilled shafts supporting the Bridge at D Street were going to be reduced in size from 4 to 3 feet to save costs. This would require new axial capacity charts for the design of the new, smaller shafts.

## SUBSURFACE CONDITIONS

### Geology

No additional geologic study was performed. Instead, the geology described in our August 2002 report was used in developing our recommendations.

### Soil Conditions

No additional explorations were performed at the site as part of this new evaluation. Instead, borings from our August 2002 report were used in the analyses.

### Groundwater

No additional groundwater measurements were taken at the site as part of this new evaluation. Instead, the groundwater level data from our August 2002 report were used in the analyses.

## GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

### French Drains

French drains installed behind the walls will reduce the lateral pressures on the wall by lowering the groundwater level to the elevation of the base of the drain. Due to the relatively poor subsurface conditions, we recommend limiting the depth of the French drains behind the walls to 10 feet to reduce the magnitude of trench caving and the costs associated with additional excavation and backfill. All the trenches should be constructed at a minimum of 0.9 meters (3 feet) in width. Trench excavation should follow the requirements outlined in WSDOT Standard Specification 7-10.3(7).

The collector pipe in the base of the French drain should be Schedule 80 PVC pipe to minimize potential damage to the drainage system during placement of the backfill. Laying the pipe in an uneven base of an excavation and assuring the pipe will drain correctly can be difficult during construction without a leveling layer of bedding aggregate. Therefore, we recommend the trench be initially backfilled with a minimum of 6 inches of aggregate material meeting the requirements of WSDOT Standard Specification 7-10.3(9) prior to placement of the PVC pipe. This will result in an even, positive gradient base to place the drainage pipe. The trenches should be wrapped with a high survivability geotextile for permanent erosion control, Class C. The trench should then be backfilled with material meeting the requirements of WSDOT Standard Specification 9-03.12(4) taking care to minimize damage to the geotextile and the PVC pipe. The geotextile should be carefully wrapped over the trench backfill with a minimum overlap of 1.5 feet. A minimum 12-inch layer of onsite material should be placed over the top of the geotextile-wrapped trench.

### Cut Slopes

Regrading the ground surface behind the wall to eliminate the 2H:1V (Horizontal:Vertical) slopes will reduce the lateral pressures on the wall. As previously discussed, additional grading to reduce wall pressures is limited to wall 7. To be effective, the regrading must extend across the entire width of the active pressure wedge that forms behind the wall. This distance can be calculated by multiplying the height of the wall by a factor of 0.7.

### Drilled Shafts

Tangent pile walls will be used to support the proposed roadway cuts and bridges at the D Street intersection. At this intersection, the tangent piles should be designed as drilled shafts. We understand that the size of the drilled shafts at this location is being reduced from 1.22 meters (4 feet) to 0.91 meters (3 feet). We understand design of the proposed bridges at the intersection of SR 543 and D Street will be performed using AASHTO Load and Resistance

Factor Design (LRFD) methodology. In accordance with this methodology, we have provided axial capacities for nominal strength (ultimate), service and extreme limit states for the smaller drilled shafts on the charts in Appendix A. Foundation support should only be considered for "structural" piles and not "lean concrete" piles. For these attached charts, we assume friction and bearing support only occur below the elevation of the roadway crossing under the proposed bridges, and not from the top of the wall. These charts include nominal capacities for end bearing and skin friction resistance for 0.91-meter (3-foot) diameter shafts. Shaft uplift capacity for the strength and extreme event limit cases can also be taken directly from the capacity charts, where the unit uplift resistance is taken as equal to the unit skin friction. Note that the capacity charts do not account for the net weight of the shafts, which should be added as a separate load when sizing the shafts (for both compression and uplift).

Resistance factors for bearing capacity and uplift for service, strength, and extreme event limit states are shown in Table 2 below:

**Table 2 - Drilled Shaft Resistance Factors**

| Limit State | Resistance Factor $\phi$ | | |
|---|---|---|---|
| | Skin Friction | End Bearing | Uplift |
| Strength | 0.65 | 0.50 | 0.55 |
| Service | 1.00 | 1.00 | 1.00 |
| Extreme | 1.00 | 1.00 | 1.00 |

After appropriate factoring (see Table 2 above) of the service and extreme event limit states charts shown in Appendix A, 25 and 150 mm (1 inch and 6 inches) of settlement, respectively, are required to mobilize these ultimate nominal capacities. Minimum tip elevations should be determined using theses capacity charts and the required loading for the appropriate design limit state.

## CONSTRUCTION CONSIDERATIONS

### French Drains

The proposed excavations for the French drains will be constructed after the drilled shafts for the retaining wall are installed. Therefore, those drilled shafts will already shore one side of the excavation. The subsurface conditions encountered along the length of the excavation for the proposed French drains will determine how the other unsupported side of the excavation behaves. For the conditions in this project where groundwater may be encountered within the trench excavations, the greatest difficulty encountered in the excavation is sidewall instability and caving. In general, stiff cohesive soils behave best, followed by soft cohesive soils and dense granular soils. The greater the amount of fines in the granular soils, the better it usually behaves. The worst conditions are where loose granular soils are encountered, especially where the granular soil is clean.

On this project we recommend all of the soils that will be encountered in the drainage trench excavations should be considered difficult to excavate in an open trench without sidewall instability and caving. Dewatering, trench boxes and/or shoring may be required to construct

the French drains in these areas. In addition, groundwater flow from sandy zones in the excavations may be initially heavy. However, experience has shown that these sandy zones are generally isolated from each other so the initial groundwater flow generally decreases rapidly as the sandy zone drains. Long term flows from these sandy zones are expected to be small. To minimize the potential for constructability problems, we recommend the trench excavations be conducted during the drier summer months and that the excavation plan include removing water from the trench either by pumping or gravity flow, whichever is feasible. The stability of temporary excavations is the responsibility of the contractor. We anticipate that shoring may be necessary in the portions of the site where difficult soil conditions are encountered. While cobbles and boulders were not encountered in the borings, based on the geologic nature of the soil units, cobbles and boulders may still be encountered in all soil units at this site.

**Backslope Regrading**

The area of proposed backslope regrading behind wall 7 is expected to encounter medium dense to very dense sand with varying amounts of silt and clay as well as stiff lean clay. This type of material is not expected to present any significant construction difficulties. However, this type of soil is susceptible to erosion, and disturbance when wet. The cut slopes should be stabilized and revegetated as soon as possible.

If you have questions or require further information, please contact William Hegge at (360) 709-5415.

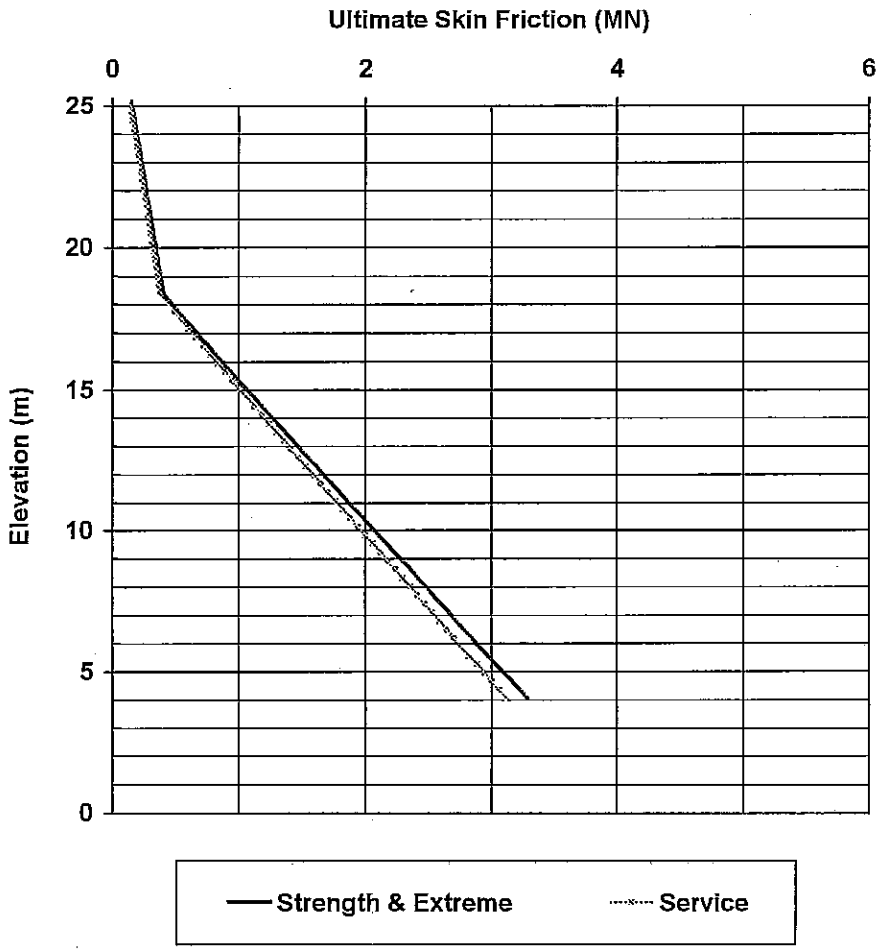
TMA:wh

cc: J. Kapur, Bridge and Structures, 47340
S. Bushnaq, Bridge and Structures, 47340
M. Sheikhizadeh, OSC Construction, 47354
C. Johnson, NW Materials Engineer, NB82-29
T. Harrison, Area Regional Administrator, NB82-210

# APPENDIX A - AXIAL CAPACITY CHARTS FOR DRILLED SHAFTS

## 0.91 Meter Diameter Shafts, D Street Bridges, SR-543, SR-5 to International Boundary

**Diameter** 0.91 M
**Casing** TEMPORARY



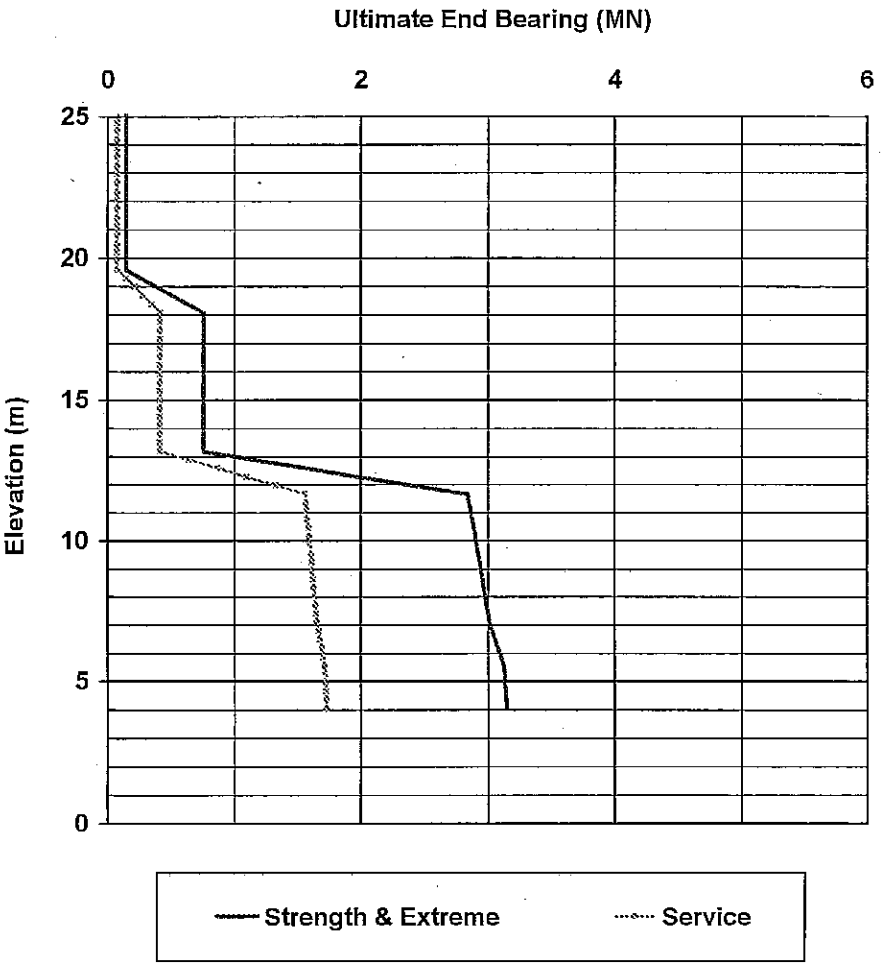
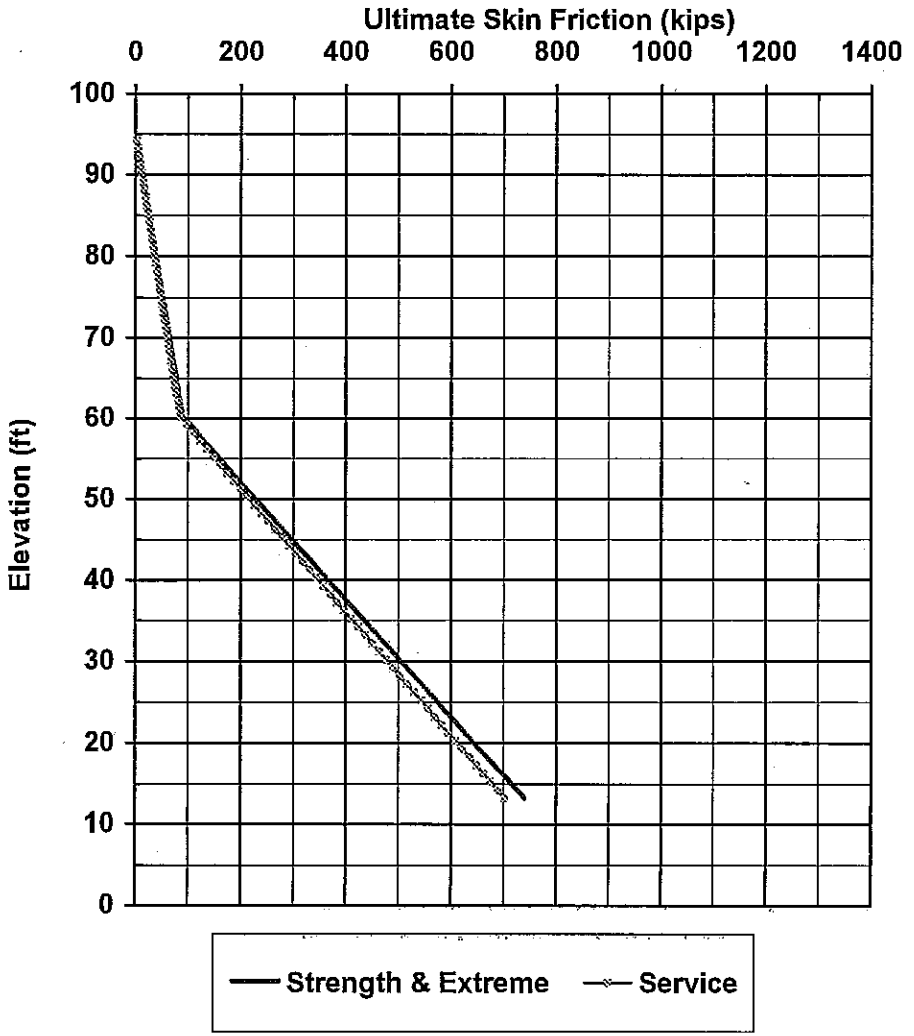




Figure E-1

## 3-Foot Diameter Shafts, D Street Bridges, SR-543, SR-5 to International Boundary

**Diameter** 3.00 FT
**Casing** TEMPORY



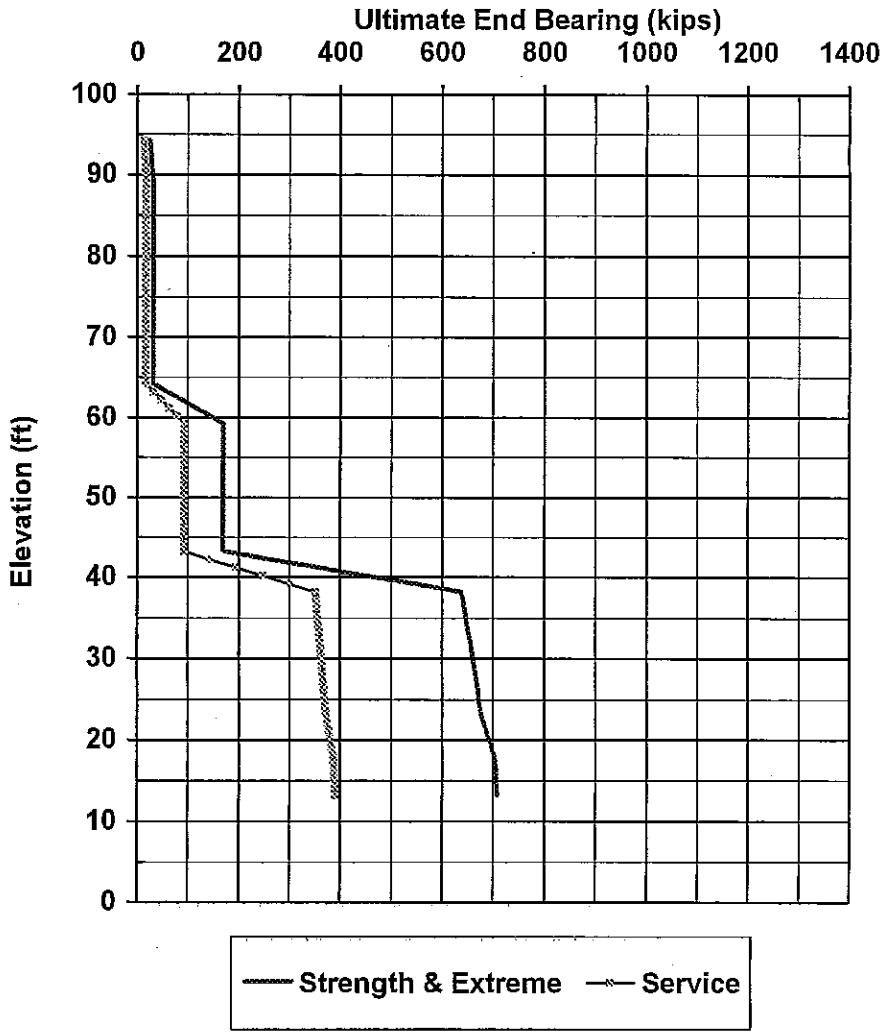




Figure E-2